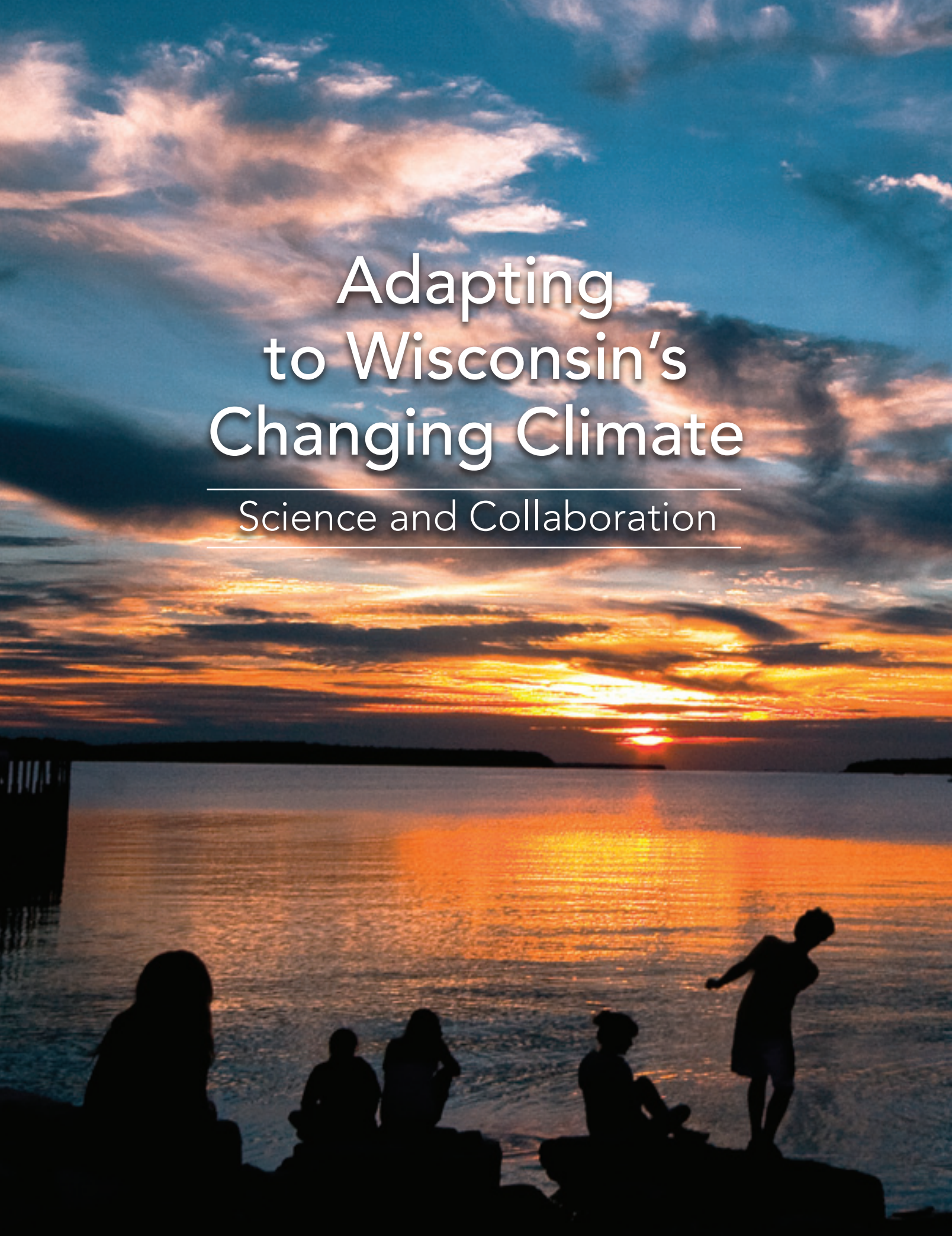


Adapting to Wisconsin's Changing Climate

Science and Collaboration

Unusual Partnerships Spawn

Model Adaptation Effort

It might seem hard to find connections between Wisconsin scientists who study ice cover on lakes, migration patterns of birds, trout stream ecology, the physics of air currents or the health effects of Milwaukee's sewer overflows. However, since 2007, these scientists — together with other experts, managers and policymakers from around the state — have gained a solid footing on undeniably common ground: Wisconsin's climate is changing and a wide array of natural and human systems are feeling the effects.

In response, this unusual gathering of experts and stakeholders teamed up to form the Wisconsin Initiative on Climate Change Impacts (WICCI), a collaborative effort that works to identify the impacts of climate change on our state and to develop ways to protect and manage natural resources and our built environment.

With more than five years of effort under its belt, WICCI is preparing the state for a future that will most likely be warmer and wetter, with more extreme weather events.

"WICCI started with many conversations between research scientists, the business community and natural resource managers who would be affected by our changing climate, and who would use our climate projection data," says Dan Vimont, an associate professor of atmospheric and oceanic sciences and climatologist in the Nelson Institute Center for Climatic Research at the University of Wisconsin-Madison.

The process of extracting local scale climate data from global models and "downscaling" it to Wisconsin was ground-breaking and is now being used across the country. "We couldn't have done this without input from other scientists and managers," says Vimont.

The project quickly took off, co-organized by UW-Madison's Nelson Institute for Environmental Studies and the Wisconsin Department of Natural Resources. More than 200 people are involved in WICCI's 16 working groups, science council, advisory committee, and outreach group, and the initiative is widely regarded as a national model of a state-level climate adaptation effort.

"WICCI is a perfect example of convening a variety of interests and different kinds of expertise to tackle a challenging issue, which the Nelson Institute is known for," says the institute's director, Paul Robbins. "It's the Wisconsin Idea in action, where we generate knowledge by linking university scholarship and research with the public and put that knowledge to work in the world."

Even after five years of research, analysis and growing partnerships, more work remains to be done. WICCI participants will continue their work to determine how a changing climate could affect the resources, seasons and regional attributes that define our state, and how we can adapt to protect the things Wisconsinites value most. •

Dan Bruell

Matthew Mitro

J. Sorbies

Devyn Caldwell

David S. Liebl

(Top to bottom) Heat and drought can impair quality apple production. Brown trout may be more resilient to warmer water temperatures than brook trout. The pasque flower blooms earlier than it did 60 years ago. Plans to deal with excessive heat will be necessary for vulnerable populations as temperatures warm. Flooding and other extreme events are likely to occur more frequently.

Confronting Change in a Critical Fishery

Few Wisconsin wildlife species are more sensitive to changes in their environment than trout. They depend on a particular set of conditions to survive, including a narrow range of cold water temperatures. Climate change poses an extraordinary challenge to this critical state resource.

Department of Natural Resources researchers John Lyons and Matthew Mitro have spent years studying the impacts of environmental change on 50 fish species in Wisconsin. They track how things like changes in land use, stream characteristics and warming temperatures affect fish populations.

For Lyons and Mitro, high-quality climate information, scaled to local conditions across Wisconsin, is extraordinarily valuable to help monitor the state's trout fisheries. Thanks to WICCI, they're getting the data they need from atmospheric scientists at the University of Wisconsin-Madison's Nelson Institute Center for Climatic Research.

The fish researchers and climate scientists met in 2007 as WICCI was being co-organized by the Nelson Institute and the Department of Natural Resources.

"This was the opportunity our climate group was looking for," says Dan Vimont, who with Chris Kucharik, co-leads the WICCI Climate Working Group. "The data we generated would be especially useful when applied to real-life issues. Impact on trout was the perfect first application."

Matthew Mitro

The Coldwater Fish and Fisheries Working Group was the first of WICCI's 16 working groups to form. Twenty-one biologists from the Department of Natural Resources, U.S. Geological Survey, University of Wisconsin System and Trout Unlimited comprise the group.

Incorporating Wisconsin-specific climate data in the fish researchers' models produced startling results: all but four of 50 species they studied would be affected. About half of them, warmwater species such as bass, could benefit from the change. But coldwater species are at risk as air and water temperatures increase. Brown trout and wild brook trout in particular have narrow temperature ranges in which they can successfully live, feed and reproduce.

Under the most extreme summer warming conditions projected by the models — where air temperatures would increase by about 9°F and water temperatures by 7.2°F — brook trout may not survive in Wisconsin at all, and brown trout may decrease by 88 percent. Even under more moderate conditions of air temperature increasing by 1.8˚F and water temperature by 0.8˚F, brook trout distributions may shrink by 44 percent and brown trout by 8 percent.

Temperature change by itself does not predict the presence or absence of fish, according to the researchers, but they say subtle effects on the life cycles or growth patterns of trout can trigger their demise.

"Trout have an optimal temperature range for feeding and growth," says Mitro, who leads the WICCI working group. "When they are forced to spend time outside that optimal range, they may not be feeding as much as when the temperatures are more suitable and when more oxygen is present. This stress affects egg production and egg development."

The Coldwater Fish and Fisheries group suggested two adaptation strategies to reduce the impact of climate warming on trout. One is to use a triage approach to identify and allocate management resources to only those coldwater streams where the fish are most likely to succeed. That could include managing for brown rather than brook trout. The second strategy is to develop activities focusing on land, shoreline, water management and in-stream restoration to offset the impacts of rising air and water temperatures and changes in precipitation.

The Department of Natural Resources is heeding these recommendations for the Driftless Area, a 23-county region in southwestern Wisconsin that holds the highest

DNR photo

Fisheries researchers are using climate projections and knowledge of fish habitat to manage resources for the future.

concentration of trout waters in the state.

The researchers are working with fish biologists and land managers to develop a 15-year master plan for thousands of acres the agency owns and manages for habitat and to provide public access to streams.

"The Driftless Area Master Plan is an excellent example of how we are using science and technology to drive strategic planning efforts," says Allen Shea, DNR's director of the Office of Business Support and Sustainability.

Fisheries ecologist Paul Cunningham co-leads the planning effort. "We're at a decision-making point of where to spend limited land acquisition dollars and our fish biologists' time," he says. "Should we focus on the limited reserves for native brook trout, or should we put our effort on brown trout that are predicted to better cope with warmer temperatures?"

The agency is seeking public input on these decisions. The plan will be completed in 2014. •

ADVANTAGE: PARASITES?

Gill lice are tiny parasites that infect only brook trout, causing gill deformities that impair the fishes' ability to obtain sufficient oxygen and release carbon dioxide, ammonia and other by-products.

Since gill lice reproduce more frequently in warm water, increased air and water temperatures may increase their opportunity to infect brook trout. On Tenny Spring Creek in Vernon County, fish research biologist Matthew Mitro observed in June 2012 that 12 percent of the brook trout were infected. By September, 26 percent were infected, and by November, 39 percent. Mitro has not found the same pattern in other streams, so he is trying to determine why some streams see an increasing infection rate while others do not.

Brook trout anglers can help track the presence or absence of gill lice through a citizen science collaboration between the Department of Natural Resources, Wisconsin Trout Unlimited and River Alliance of Wisconsin. Anglers can use an on-line reporting form (http://wisconsintu.org/Survey/tabid/468/Default.aspx) to submit their observations. A paper form is also available through Wisconsin Trout Unlimited.

Whether or not gill lice are present, anglers should disinfect their gear with a bleach solution prior to fishing in the next stream to prevent the potential spread of parasites, invasive species and diseases.

Matthew Mitro

Gill lice are found only on brook trout such as this one in Ash Creek, Richland County. The parasites compromise the fish's ability to obtain sufficient oxygen and release carbon dioxide.

Disturbing Nature's
Sense of Time

The early bird gets the worm, and that bird is arriving earlier — not by the clock but by the calendar. The American Robin, Wisconsin's state bird, arrives earlier in the spring — 13 days earlier in 2010 than it did in 1990, according to scientists who track bird migration patterns.

"For both amateur bird enthusiasts and professional researchers, the American Robin is the classic harbinger of spring," says Ben Zuckerberg, a UW-Madison assistant professor of forest and wildlife ecology and a member of WICCI's Wildlife Working Group.

Data collected by citizens involved in "Project FeederWatch" have been instrumental in tracking the presence and abundance of birds throughout the United States and Canada. Wisconsin's robin-sighting records reflect that Wisconsin is warming, particularly in the spring.

Since robins don't fly far from Wisconsin in the winter, their migration is primarily influenced by temperature changes in the region. Migratory patterns of species that overwinter farther away are influenced more by changes in daylight rather than temperature.

Climate models for Wisconsin project that springtime temperatures are likely to warm by 3-9°F by the middle of the century, with the largest increases across northern and central Wisconsin. Warmer temperatures will affect the timing of life-cycle events, or phenology, of plants and animals.

Robins may be on the list of winners when it comes to climate change. Species that have short generation times, live and move across wide landscapes and can live most anywhere, including highly populated areas, will survive better than species that are more specialized in their feeding and habitat needs. We can expect to see more gray squirrels, white-tailed deer, European starlings and Canada geese, but fewer, if any, American marten, red-backed salamanders, spruce grouse and common loons.

Peter McIntyre, a member of WICCI's Water Resources Working Group, is looking at how climate change is altering fish migration patterns that flow to the Great Lakes.

"We're using climate forecasting to predict how fish migration patterns might change," says McIntyre. "Great Lakes water temperatures appear to be changing faster than air temperatures."

McIntyre, an assistant professor in the University of Wisconsin-Madison Center for Limnology, is investigating whether stream flow or temperature triggers suckers' impulse to spawn.

Suckers, an important food source for large sport fish, usually start to move when the days are warm and the water is clear but before the trees have leafed out. The eggs and excrement they deposit as they move upstream serve as an important source of nutrients that fertilize the growth of plants and insects in spawning streams.

If peak migration of suckers shifts, their interactions with migrating sturgeon, pike, walleye and redhorse would also be affected. In fact, changing

Britta Heise

Wisconsin's state bird, the American Robin, arrives 13 days earlier in the spring than it did in 1990.

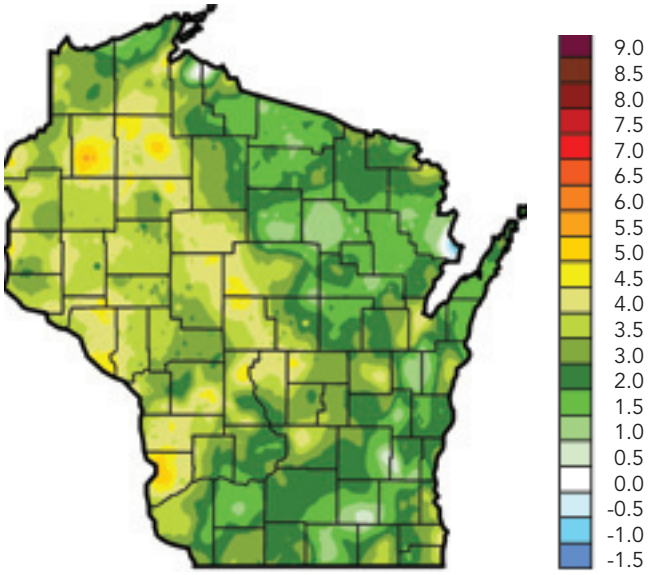
the timing of the nutrient inputs from suckers could alter the dynamics of the entire stream ecosystem.

Like Zuckerberg and his bird-watchers, McIntyre is using citizen volunteers to collect some of the data used in his study. Citizen scientists through the University of Wisconsin Extension — DNR Water Action Volunteers program are monitoring sucker migration patterns on 22 tributaries to Lake Michigan. They devote about 15 minutes at the same time each day for up to five weeks in the spring looking for suckers moving upstream.

DNR research scientist Karl Martin heads WICCI's Wildlife Working Group. His group focuses on developing adaptation strategies for wildlife management that can change along with environmental conditions. At the top of his list is land protection for different types of habitat as migratory, breeding and foraging behaviors change with the alteration of Wisconsin's seasons. Martin says good stewardship, private-public partnerships and citizen involvement can help promote resilience in wildlife habitat and populations.

Wildlife managers and biologists across the state were surveyed by Suzanne Hagell, a research associate on WICCI's Wildlife Working Group. "This group realizes that their hard work might not pay off for a long time," says Hagell, "but they are highly motivated to develop climate change adaptation strategies, not just for birds but for all wildlife." •

CHANGE IN SPRING AVERAGE TEMPERATURE (ºF) FROM 1950 TO 2010



Michael Notaro, UW-Madison Center for Climatic Research

Spring is arriving six to 12 days earlier in Wisconsin. Average springtime temperatures show a warming trend between 1950 and 2010.

Coggin Heeringa

School groups, scouts and weekend visitors monitor spring fish migration in a citizen science project providing data for a UW-Madison research project. "One second-grader told me that the sucker run is better than fireworks," says Coggin Heeringa, from The Crossroads at Big Creek, a 115-acre nature preserve in Sturgeon Bay, Wis.

Coping with Extremes

Madeline Gotkowitz

Drought, heat waves, heavy rainfall and other extreme weather events are likely to become more common in Wisconsin's future, according to WICCI climate scientists. For example, they say southern Wisconsin will see significant increases in rain events that dump one, two or three inches in a 24-hour period. The state may also see as many as 60 days per year where the temperature tops 90˚F by the end of this century, with more than 14 days over 100˚F. The scientists also expect fewer winter nights below 0˚F.

Steve Vavrus is a senior scientist at the Nelson Institute Center for Climatic Research at the University of Wisconsin-Madison and a member of the WICCI Climate Working Group. Vavrus has studied extreme events in the United States that occurred over the last century. He is interested in the impacts they pose on ecosystems, agriculture, human health, stormwater management, infrastructure and the economy.

"It's so difficult to give a 'yes' or 'no' answer to the question I frequently get: Can we attribute extreme events to global warming?" says Vavrus. "The answer is usually yes and no. We can never prove that a certain event occurred because the climate is changing, but hopefully, we can determine how much climate change has loaded the dice for these events to occur."

The Midwest has experienced plenty of extremes in the recent past. The heat wave of 1995 brought temperatures over 100˚F, along with extremely high humidity. More than 750 heat-related deaths were reported in Chicago.

In 2012, the weather was particularly weird in Wisconsin, with record-breaking March temperatures more typical of June and July. A cold snap in April was followed by a heat-wave in July. Madison experienced 104˚F as part of a three-day streak over 100˚. A mild fall followed, with late-November snow falling in the north on ground that had yet to freeze.

All communities should develop heat wave action plans, stresses Vavrus. During the 2012 heat wave, the city of Madison opened its convention facility as a public cooling center for those with no air conditioning. The city also provided free bus transportation to the downtown location.

Weather forecasting for extreme events has become much more accurate than in the past, according to Vavrus, providing the opportunity to prevent negative health impacts. Organizers of the 2012 Madison Marathon used the forecast of unusually hot weather to make the decision to cancel that year's event. The day turned out to be 94°F, too risky for a long running event.

"I can't emphasize enough how much that hot weather, which we'll be seeing more of in the future, is a deadly serious health risk," Vavrus says. "Heat action plans can save lives."

Additionally, the apple crop was almost a complete failure in Door County and other parts of the state. The March warming that lured people to break out their shorts and flip flops also encouraged fruit trees to come into blossom — but the cold snap that followed put an abrupt end to the season before the fruit could even set.

The state has also seen extremes in precipitation in the recent past. The 14 inches of rain that fell over a two-week period in the south central part of the state in 2008 was in sharp contrast to the continuing drought that plagued the northern part of the state, where piers stood high and dry over disappearing lakes. The heavy rain wiped out sections of the interstate, made sewage treatment plants overflow their capacities, and caused $34 million in damage to municipal infrastructure.

Carolyn Rumery Betz

Long-term drought can change the way we do business. In the Driftless Area of the state, some farmers irrigated their crops in 2012, something rarely done on silt-loam soils. Pumping groundwater can alter the hydrologic system in that part of the state.

Kyle MacDonald

In addition to the health risks and discomfort, extreme weather can have serious economic consequences. Wisconsin lost almost all of its maple syrup production due to the extreme March heat of 2012, when night-time temperatures refused to drop below freezing, a necessary component of the sugaring cycle.

Communities like Spring Green and Brodhead experienced groundwater flooding, a process by which the water table rises so high that it ponds on the surface. After five months of pooled groundwater in a neighborhood in Spring Green, the Federal Emergency Management Agency (FEMA) spent $5.37 million to buy out 28 homes, the first such action for groundwater flooding in the country. Wisconsin hydrogeologists expect this kind of flooding to occur more frequently in the future.

Wisconsin should be proactive in developing adaptation strategies to cope with extreme events, according to climate experts.

David S. Liebl, an outreach specialist with University of Wisconsin-Cooperative Extension and a WICCI member, is working with county Extension agents to improve their understanding of climate change so they can help individuals and communities prepare for extreme events.

"From family living agents working with the elderly and vulnerable populations to prepare for heat waves, to agricultural agents working with farmers on installing cooling systems for their cows, Extension agents are in a prime position to help others address vulnerabilities," he says.

Liebl and University of Wisconsin-Madison engineering professor Ken Potter have been working with municipalities to address climate impacts on stormwater infrastructure, their area of specialty. They believe that some communities will need to handle larger stormwater flows to prevent flooding, combined stormwater overflows and the health-related consequences from these events, such as mosquito infestations and mold growth in homes. •

Planning to Protect

Community Assets

Climate change is a global phenomenon, but it poses a growing list of challenges at the local level. Helping municipalities adapt to climate change is the focus of WICCI's Community Adaptation Working Group, directed by DNR's Land Use Team Leader, Sally Kefer.

Kefer has crossed the state over the past few years to help communities plan for climate change. She and other WICCI members have been to Eau Claire, Madison, River Falls and La Crosse, and they have participated in federally sponsored workshops in Milwaukee, Green Bay and Duluth/Superior.

WICCI climate models project that Wisconsin will experience increasing temperatures along with more frequent and intense rain events.

Storms that drop two or three inches in a 24-hour period occur today about 12 times per decade in southern Wisconsin, and seven times per decade in northern Wisconsin. By mid-century, these are likely to occur about 25 percent more frequently and increase slightly in intensity.

Rawle C. Jackson

The frequency of very hot days (over 90°F) will likely double, from roughly 12 per year to 25. Planning ahead for these changes can help communities become more resilient.

"I want to show communities that they can help themselves to successfully handle the effects of extreme events," says Kefer. "They need to protect both public health and community infrastructure."

Teaming up with the Department of Health Services, Kefer landed a grant to help La Crosse identify areas of vulnerability, including health-related challenges and other issues that result from flooding, extreme heat, and increased runoff from adjacent agricultural lands.

La Crosse, a city of 51,000, then received a federal grant to address some of these issues by developing plans for and installing "green infrastructure" in an older, flood-prone residential area. Excess water coming from intense rain events will be directed into grass swales or curbside gardens, where it can soak into the ground instead of flowing over hard street surfaces, causing flooding.

"Cities can easily amend some of their existing community plans and budget decisions to deal with our changing climate," says Kefer. "Most communities already have sustainability, emergency management, forestry, and utility and engineering plans that can be amended to help plan for what we envision is coming: more flooding, higher temperatures, and more freezing and thawing, which can affect driving conditions and infrastructure."

La Crosse County and the Mississippi River Regional Planning Commission will address these issues through an "All Hazards Mitigation Plan."

"By using green infrastructure, we can do some things to address the increased runoff without a great deal of added expense," says assistant city engineer Bernard Lenz. Source controls can be added during routine street construction and save the city money in the long run.

La Crosse officials are aware that they must develop strategies to protect their most vulnerable citizens, the elderly and economically disadvantaged. High on the list is the need for cooling centers and modes of transportation that can bring those without air-conditioning to places where they can find safe shelter from heat waves. The La Crosse County Health Department is working on the issue.

As La Crosse continues to incorporate climate adaptation into community plans and action, other communities are beginning to identify their own areas of vulnerability. Erosion from stormwater, flooded buildings and highways, excessive gullies and collapsing slopes are examples of stresses that can compromise a city's health and ability to function. •

Sally Kefer

Community workshops, such as this one in La Crosse, help identify and address vulnerabilities related to our changing climate. They need to protect both public health and community infrastructure.

Adaptation in Education

The global scale of climate change, and the long time span over which it occurs, can make it a difficult topic for educators. But two Wisconsin environmental education centers are meeting the challenge with new educational exhibits: the Aldo Leopold Nature Center in Monona and the Northern Great Lakes Visitor Center in Ashland.

The Aldo Leopold Nature Center has expanded its traditional environmental education experience for school-age children with its climate exhibit. Combined with "high-touch" outdoor programs, the new "high-tech" exhibit uses multimedia and interactive programming, including digital, visual, hands-on and immersive experiences for all ages.

Exhibit highlights include "Science on a Sphere," a high-definition global projection system that displays NOAA and NASA planetary data, and "Global Warming: Facts and Our Future," a powerful interactive exhibit developed by the Marian Koshland Science Museum of the National Academy of Sciences.

With the recent additions, the Aldo Leopold Nature Center will serve even more school-aged visitors each year — nearly 50,000 and counting. Educational content and programming meet national standards for science literacy.

"This digital curriculum allows us to be flexible and current," says Brenna Holzhauer, the center's manager of exhibits and digital curricula. "Using touch-screen technology, we're able to regularly update our content and ensure that it is accessible and relevant at the local level."

The exhibit uses information from WICCI's 2011 report, which identifies climate change impacts and adaptation strategies. The Aldo Leopold Nature Center uses a dozen videos (found at climatewisconsin.org) developed by the Wisconsin Educational Communications Board that focus on how climate change affects agriculture, forestry, trout fishing and other fundamental Wisconsin attributes.

The Northern Great Lakes Visitor Center in Ashland also uses WICCI resources in its exhibit, Gikinoo'wizhiwe Onji Waaban (Guiding for Tomorrow), or "G'WOW." The "Changing Climate, Changing Culture" exhibit integrates climate science with place-based evidence of how climate change is affecting the natural resources used by the Ojibwe. The exhibit is part of a larger outreach effort that, like the Aldo Leopold Nature Center, uses touchscreen technology to deepen the learning experience.

Bringing Native perspectives into the conversation is important because the Ojibwe, like other tribes, rely on traditional, local resources such as wild rice that may dramatically change under a warmer, drier climate.

"The G'WOW Initiative helps people discover that culture and science agree — climate change is real," says Cathy Techtmann, UW-Extension environmental outreach specialist based at the Great Lakes Visitor Center. "Visitors can see how climate change is affecting Native traditional cultural practices, how it is affecting their culture and community, and what they can do about it." •

Aldo Leopold Nature Center

The Aldo Leopold Nature Center is visited by 50,000 students each year.

Cathy Techtmann

Teachers participate in a climate literacy workshop with Apostle Islands' National Lakeshore park superintendent and WICCI member Bob Krumenaker, an expert on climate change impacts on the country's National Parks.

Charles Rasmussen, GLIFWC

Joe Rose, Sr. explains that the G'WOW exhibit is designed to increase knowledge of how climate change is affecting Lake Superior's environment, its communities and Native American cultures.

Written by Carolyn Rumery Betz and edited by Steve Pomplun, University of Wisconsin-Madison, Nelson Institute for Environmental Studies. Assistance provided by Paul Cunningham, Suzanne Hagell, Brenna Holzhauer, Sally Kefer, Danielle Lamberson Philipp, Richard Lathrop, David S. Liebl, John Lyons, Karl Martin, Matthew Mitro, Peter McIntyre, John Pohlman, Ken Potter, Jack Sullivan, Cathy Techtmann, Steve Vavrus, Dan Vimont and Ben Zuckerberg.

Cover photo: Fotophilius

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For more information about the Wisconsin Initiative on Climate Change Impacts, visit wicci.wisc.edu.

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